CHAPTER 3

FY 2006 BENEFITS ESTIMATES

The Office of Energy Efficiency and Renewable Energy (EERE) estimates expected benefits for its overall portfolio and for each of its 11 programs. Benefits for the FY 2006 budget request are estimated for the midterm (2010-2025) and long term (2030-2050). Two separate models suited to these periods are employed—NEMS-GPRA06 for the midterm and MARKAL-GPRA06 for the long term.

Benefits estimates are intended to reflect the value of program activities from 2006 forward. They do not include the impacts of past program success, nor technology development or deployment efforts outside EERE's programs. This distinction is difficult to implement in practice, because many research and deployment activities provide continuous improvements that build on past success; and because EERE programs are leveraged with private-sector and other government efforts (*e.g.*, in addition to the Baseline Case, private-sector improvements).

Outcomes and Benefits Metrics

The energy efficiency improvements and additional renewable energy production facilitated by EERE's programs reduce the consumption of traditional energy resources. Reducing energy consumption affords the Nation a number of economic, environmental, and energy security benefits.[1] The extent of these benefits depends on numerous factors including which energy sources are reduced, the costs of the new technologies, and the emissions performance of the energy technologies used. Different EERE portfolios would produce a different mix of benefits, even if the overall level of primary energy savings were the same.

The public benefits resulting from these reductions in the use of traditional energy resources take many forms. Environmental improvements, for instance, can include reductions in local, regional, or global air emissions; reduced water pollution; noise abatement, etc. These public benefits are typically difficult to measure directly, and some aspects are not quantifiable. EERE has developed a set of *indicators* intended to provide a sense of the magnitude and range of the benefits its programs provide the Nation. EERE estimates benefits for the following defined metrics:

Primary Outcome:

> **Energy Displaced - the difference in nonrenewable energy consumption with and without the technologies and market improvements developed by EERE programs.**

[1] This is a categorization of EERE's benefits estimates, based on the framework developed by a National Research Council (NRC) committee. The framework is described in more detail in the Introduction.

Analysts measure energy savings on a primary basis, accounting for the energy consumed in producing, transforming, and transporting energy to the final consumer. Energy savings from underlying private-sector improvements in technologies are not counted. Energy displaced is reported in quadrillion Btus per year (quads/yr).

Primary Benefits:

Economic Benefits: Economic benefits are the potential for EERE technologies to make energy more affordable by reducing expenditures on energy and energy services, increase economic productivity and GDP through more efficient production processes, reduce the impact of energy price volatility on the U.S. economy by providing more efficient technologies and providing alternative energy sources, and improve the balance of trade by exporting energy technologies. Of these, EERE currently estimates two aspects of affordability—energy-expenditure savings and total system cost savings:[2]

Energy-expenditure savings – The difference in total consumer energy bills with and without the availability of technologies and market improvements developed by EERE technologies. This is an estimate of energy bill savings[3] and does not include all incremental costs to end users of acquiring the new technology. The EIA NEMS model does not currently have the capability to provide net costs in all sectors of the economy. Energy-expenditure savings are reported in billions of 2002 dollars per year.

Total system cost savings – The difference in total systems costs with and without the availability of technologies and market improvements developed by EERE technologies. Total system cost represents the economic cost to society to produce, import, convert, and consume energy. It is calculated as the sum of domestic resource-extraction costs, imported fuel costs, and the annualized capital and operating and maintenance costs of energy technologies (including end-use demand devices). Total system cost savings is a net estimate of system costs generated by MARKAL-GPRA06, which unlike the energy expenditure savings estimates generated by NEMS-GPRA06, includes the incremental costs of end-use technologies. Total system cost savings are reported in billions of 2002 dollars per year.

Environmental Benefits: Environmental benefits that can result from use of EERE technologies include, among many others, lower carbon, SOx, NOx, and other air emissions. Of these, EERE currently estimates only the impacts of its programs on carbon emissions:

Carbon savings (*i.e.*, emission reductions) – The difference in the level of U.S. energy-related carbon emissions with and without the availability of EERE technologies and associated market improvements. Carbon emission reductions result from the reductions in fossil fuel consumption when these new supply (renewables) and

[2] Energy-expenditure savings are calculated through 2025 using the NEMS-GPRA06. Total system cost savings are calculated through 2050 using MARKAL-GPRA06.

[3] Energy efficiency improvements and increased use of nonfuel renewable energy (*e.g.*, renewable-generated electricity) reduce energy bills in two ways. Consumers who make energy efficiency or renewable energy investments benefit directly through reduced purchases of energy (quantity component). In addition, the lower demand for energy reduces the price of energy for all consumers (price component).

demand (energy-efficient) technologies are used in the market. As with the energy-savings metric, emission reductions count the effect of upstream energy savings in producing, transforming, and transporting energy to the end user. Carbon savings are reported in million metric tons of carbon (mmtc) equivalent per year.

Security Benefits: Security benefits include improvements in the reliability of fuel and electricity deliveries, reduced likelihood of supply disruptions, and reduced impacts from potential energy disruptions. EERE contributes to these security gains by reducing U.S. reliance on imported fuels, increasing the diversity of domestic energy supplies, increasing the flexibility and diversity of the Nation's energy infrastructure, reducing peak demand pressure on that infrastructure, and providing backup energy sources in the event of outages. Of these aspects of energy security, EERE has developed indicators related to concerns about fuel supplies and the reliability and diversity of electricity supplies:[4]

Oil savings – The difference in total U.S. oil consumption with and without EERE technologies and market improvements. Oil savings are reported in million barrels per day (mbpd).

Natural gas savings – The difference in total U.S. natural gas consumption with and without EERE technologies and market improvements. Natural gas savings are reported in quadrillion Btu per year (quads/yr).

Avoided additions to central conventional power – The difference in central conventional power additions with and without EERE technologies and market improvements. Avoided central conventional power additions result from electricity capacity displaced by efficiency improvements; additional distributed generation capacity (fossil or renewable); and central renewable power-generating capacity.[5] Avoided capacity additions are reported in cumulative gigawatts (GW).

In interpreting these metrics, it is important to remember that while the benefits of efficiency and renewable technologies are multifaceted, they are not always distinct or additive. Improvements in balance-of-trade or economic productivity, for instance, are contributory to improved GDP and not additional to improved GDP. Nonetheless, identifying the various types of economic or other contributions can help relate EERE's portfolio to various economic or other policy concerns.

Each of these metrics is ideally measured as a net benefit (*e.g.*, energy bill savings minus the cost to the consumer of investing in the efficient or renewable technology, or including positive and negative environmental impacts). Analysts calculate carbon emission reductions, as well as oil and natural gas savings, on a net basis, including cases in which EERE programs tend to increase rather than decrease use or emissions. While consumer-expenditure estimates calculated by

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[4] The inclusion of reliability improvements within the security category was part of the NRC suggestions on how to structure the types of EERE benefits.

[5] These measures are not additive and are not the same as a measure of peak-load reduction for conventional electricity or of improved reliability. Renewable capacity additions are not equivalent to capacity additions avoided because of differences in capacity factors and coincidence of renewable generation at system peak (*i.e.*, peak electricity-generation output of wind, for example, may not coincide with the peak demand of the utility system to which it supplies power).

NEMS-GPRA06 do not reflect the costs to consumers of purchasing more efficient or cleaner technologies, MARKAL-GPRA06 is able to provide estimates of net economic costs.

Portfolio Benefits

Table 3.1 shows the estimated economic, environmental, and security benefits of EERE's overall portfolio of investments in improved energy-efficient technologies, renewable energy technologies, and assistance to consumers in adopting these technologies. Data by five-year increments (2010 to 2025) are shown for NEMS-GPRA06 and by 10-year intervals (2020 to 2050) for MARKAL-GPRA06.[6]

Table 3.1. Annual EERE Portfolio Benefits for FY 2006 Budget Request for Selected Years[7,8]

EERE Midterm Benefits (NEMS-GPRA06)	2010	2015	2020	2025
Energy Displaced				
• Primary nonrenewable energy savings (quadrillion Btu/yr)	1.1	3.4	7.8	12.3
Economic				
• Energy-expenditure savings (billion 2002 dollars/yr)*	12	37	87	123
Environment				
• Carbon dioxide emission reductions (mmtc equivalent/yr)	22	67	160	262
Security				
• Oil savings (mbpd)	0.1	0.6	1.3	2.3
• Natural gas savings (quadrillion Btu/yr)	0.5	1.1	1.9	1.8
• Avoided additions to central conventional power (cumulative gigawatts)	5	49	96	137

EERE Long-Term Benefits (MARKAL-GPRA06)	2020	2030	2040	2050
Energy Displaced				
• Primary nonrenewable energy savings (quadrillion Btu/yr)	8.0	17.7	28.2	33.6
Economic				
• Energy-system cost savings (billion 2002 dollars/yr)*	43	102	188	282
Environment				
• Carbon dioxide emission reductions (mmtc equivalent/yr)	152	364	568	699
Security				
• Oil savings (mbpd)	1.3	4.6	9.0	11.0
• Natural gas savings (quadrillion Btu/yr)	3.1	2.8	3.6	2.4

* Midterm energy-expenditure savings only include reductions in consumer energy bills, while long-term energy-system cost savings also include the incremental cost of the advanced energy technology purchased by the consumer.

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[6] NEMS-GPRA06 runs using one-year intervals, while Markal-GPRA06 runs using five-year intervals.

[7] Estimates reflect the annual benefits in each year associated with program activities from FY 2006 to the benefit year, or to program completion (whichever is nearer), and are based on program goals developed in alignment with assumptions in the President's Budget. Midterm program benefits were estimated using the GPRA06-NEMS model, based on the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) and using the EIA's *Annual Energy Outlook 2004* (*AEO2004*) reference case. Long-term benefits were estimated using the GPRA06-MARKAL model developed by Brookhaven National Laboratory. Results can differ among models due to structural differences. The models used in this analysis estimate economic benefits in different ways, with MARKAL reflecting the cost of additional investments required to achieve reductions in energy bills.

[8] For some metrics, the benefits estimated by MARKAL-GPRA06 do not align well with those reported by NEMS-GPRA06. Every attempt is made in the integrated modeling to use consistent baselines, input data and assumptions in both models to produce consistent results. However, NEMS and MARKAL are in some respects fundamentally different models (see Boxes 4.1 and 5.1). Discrepancies in the estimated benefits often occur simply because of these model differences.

Energy Displaced: EERE's portfolio significantly dampens the expected growth in nonrenewable energy consumption. Absent the results of EERE's programs,[9] energy use is expected to grow by nearly 32 quads from 2005 to 2025, to about 127 quadrillion Btus of energy and by 44 quads from 2005 to 2050. If the goals of EERE's investment portfolio are achieved and the corresponding market outcomes realized, it will reduce nonrenewable energy consumption by more than 12 quadrillion Btu by 2025, or about 39 percent of the expected incremental growth in energy demand over this time period; and by 34 quadrillion Btus by 2050, or about 76 percent of the expected incremental growth in energy demand over this time period (see **Figure 3.1**). This results in a reduction of nonrenewable energy consumption starting in 2030 despite a growing economy.

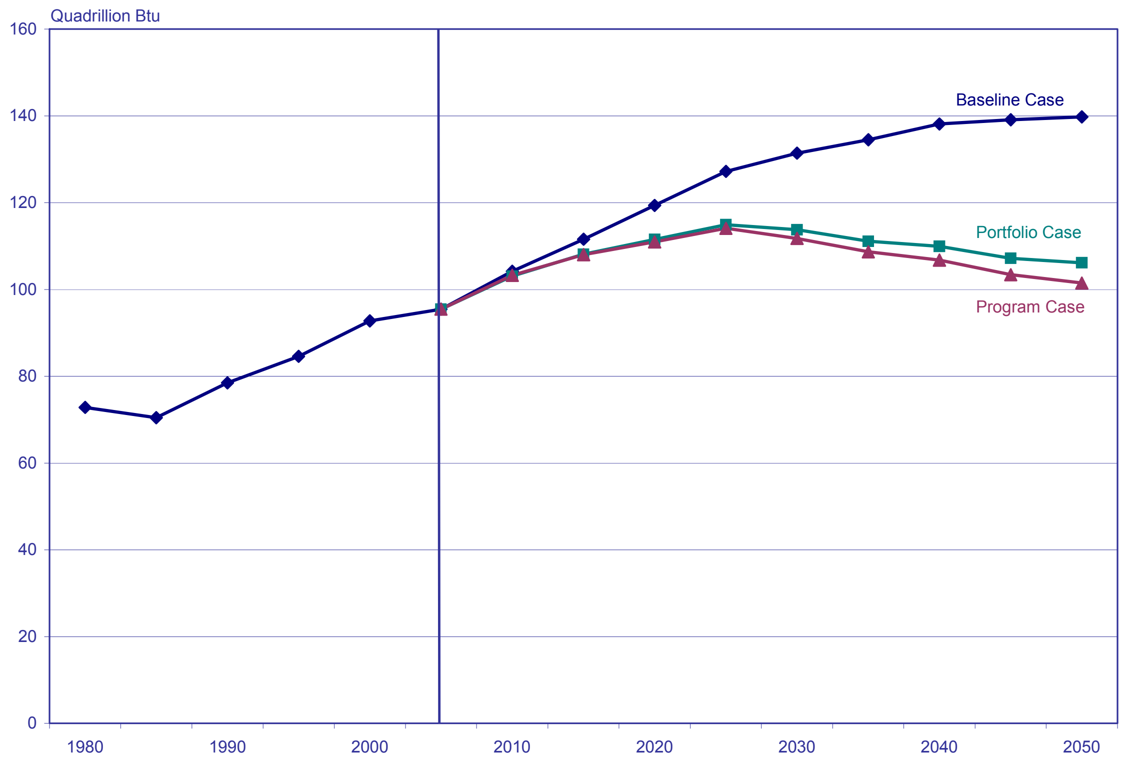

Figure 3.1. U.S. Nonrenewable Energy Consumption, 1980-2000, and Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

These estimates account for interactions among program results. While some program activities reinforce each other to produce larger benefits than would be evident from each program's individual efforts, programs compete for the same markets in other cases. For example, the various renewable technology programs compete in the electricity-generation market. In addition, activities being funded by some programs reduce the potential market for technologies being developed in other programs. As an example, reductions in electricity demand due to efficiency improvements reduce the size of the generation market and,

[9] See Chapter 1 for information on how EERE's "no-program" Baseline Case is developed.

therefore, the market opportunity for renewable-generation technologies. The overall effect of these interactions is to reduce estimated benefits by about 0.8 quads in 2025 compared to the sum of the individual program benefits; and to reduce estimated benefits by about 4.6 quads in 2050 compared to the sum of the individual program benefits (*i.e.*, Program Case, see **Figure 3.1**).

Economic Benefits: The energy savings resulting from these efficiency and renewable energy contributions are estimated to reduce annual consumer energy expenditures in 2025 by $123 billion (expressed in real 2002 dollars) relative to the baseline projection of $1,015 billion (**Figure 3.2**), or about 12 percent of the nation's expected energy bill.

While these energy bill savings appear to be large, they represent both reduced energy purchases and lower energy prices resulting from reductions in demand. They also exclude incremental costs to end users of acquiring the new technology, because the EIA NEMS model does not currently have the capability to determine this in all sectors of the economy. Lower energy demand dampens fuel costs and reduces the need for expensive new energy infrastructure expenditures. Lower energy prices improve affordability for all consumers, including those who make no additional efficiency or renewable investments as a result of EERE's activities.

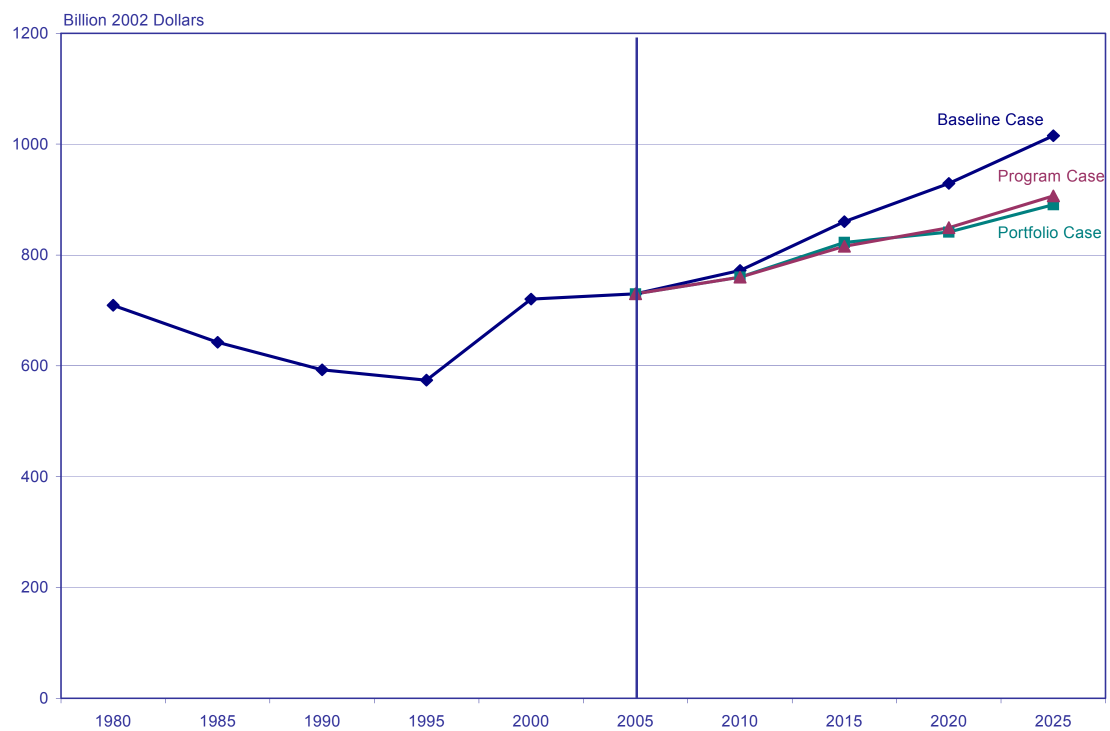

Figure 3.2. U.S. Total Energy Expenditure, 1980-2000, and Projections to 2025: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 3.4 and Table D1, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

The EERE portfolio also will reduce annual total system energy costs by $282 billion (in real 2002 dollars) in 2050 (**Figure 3.3**). This longer-term analysis is done using MARKAL-GPRA06, which includes the incremental costs to end users of acquiring the new technology.

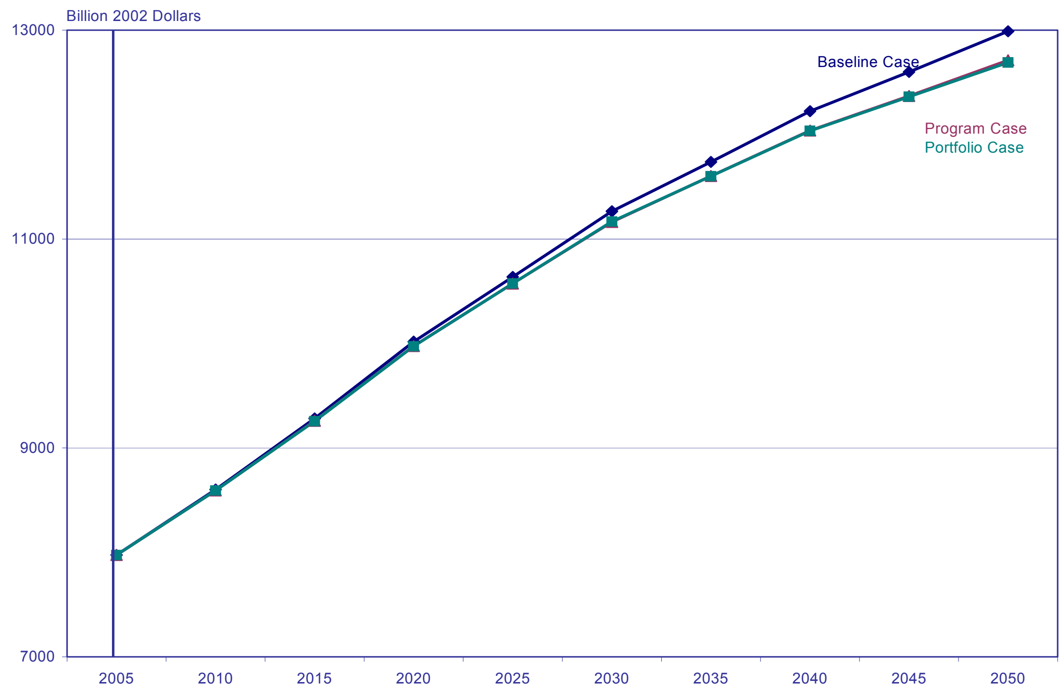

Figure 3.3. U.S. Total Energy-System Cost Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: MARKAL-GPRA06

Environmental Benefits: Annual carbon emissions are projected to be 262 million metric tons (carbon equivalent) less than the 2025 baseline projection of 2,219 million metric tons—a reduction of about 12 percent (**Figure 3.4**) or 45 percent of the expected increase from 2005 to 2025.[10] Annual carbon emissions are projected to be 699 million metric tons (carbon equivalent) less than the 2050 baseline projection of 2,621 million metric tons—a reduction of about 27 percent or 71 percent of the expected increase from 2005 to 2050.

Although not quantified here, EERE's portfolio contributes toward improved regional and local air quality through reduced SO_2 and NOx emissions from fossil energy consumption (SO_2 reductions in the utility sector are likely to lower permit prices rather than reduce net emissions). The portfolio also provides State and local governments with additional options for meeting Clean Air Act ambient air quality standards. For instance, the Clean Cities activity in the Weatherization and Intergovernmental Program facilitates local purchases of alternative-fuel vehicles.

[10] To meet the 2012 target under President Bush's Climate Change Initiative, emissions – from energy consumption – would need to be 1,754 mmtce (an 18 percent reduction). The Baseline projection is 1,843 mmtce, which is a 13.8 percent reduction in carbon intensity from 2002. With the EERE Portfolio, emissions are projected to be 1,806, or a 15.6 percent intensity reduction from 2002. The EERE Portoflio, therefore, is expected to contribute 43 percent of the reduction toward the goal.

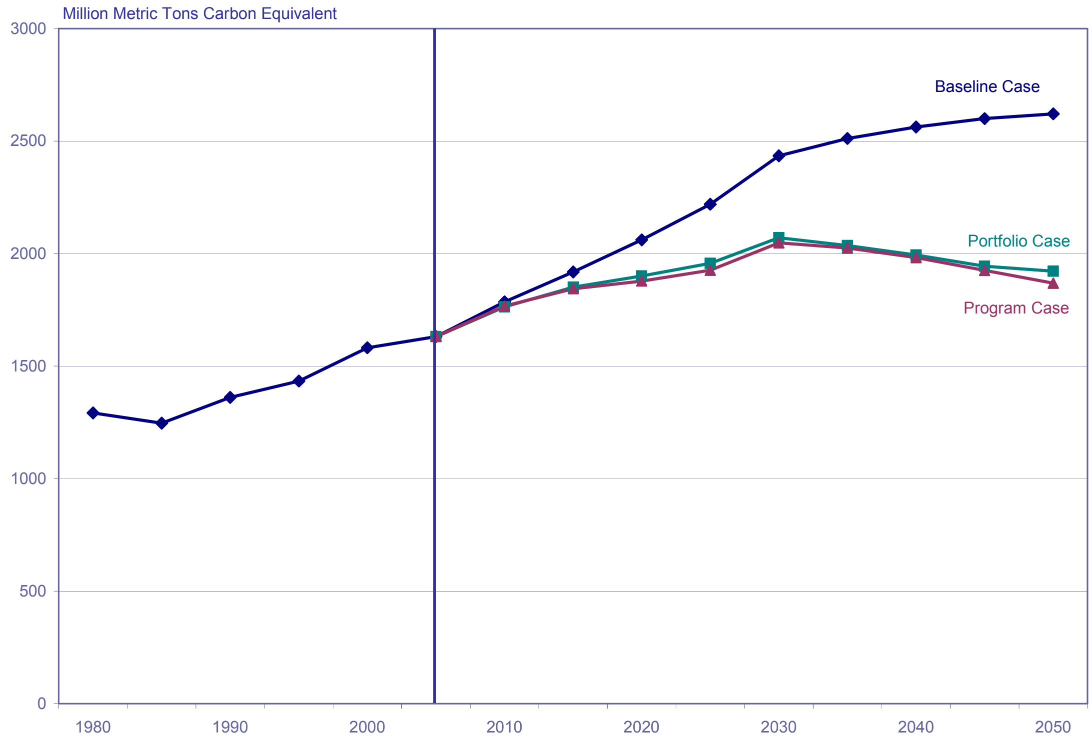

Figure 3.4. U.S. Carbon Emissions, 1980-2000, and Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 12.2, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

Security Benefits: The EERE portfolio is expected to reduce annual oil consumption by 2.3 mbpd from the 2025 baseline of 26 mbpd, or about 34 percent of expected growth in oil demand between 2005 and 2025 (**Figure 3.5**). The portfolio is expected to reduce oil consumption by 11 mbpd from the 2050 baseline of 30.5 mbpd (about 99 percent of expected growth in oil demand between 2005 and 2050). This results in declining oil consumption starting in 2030.

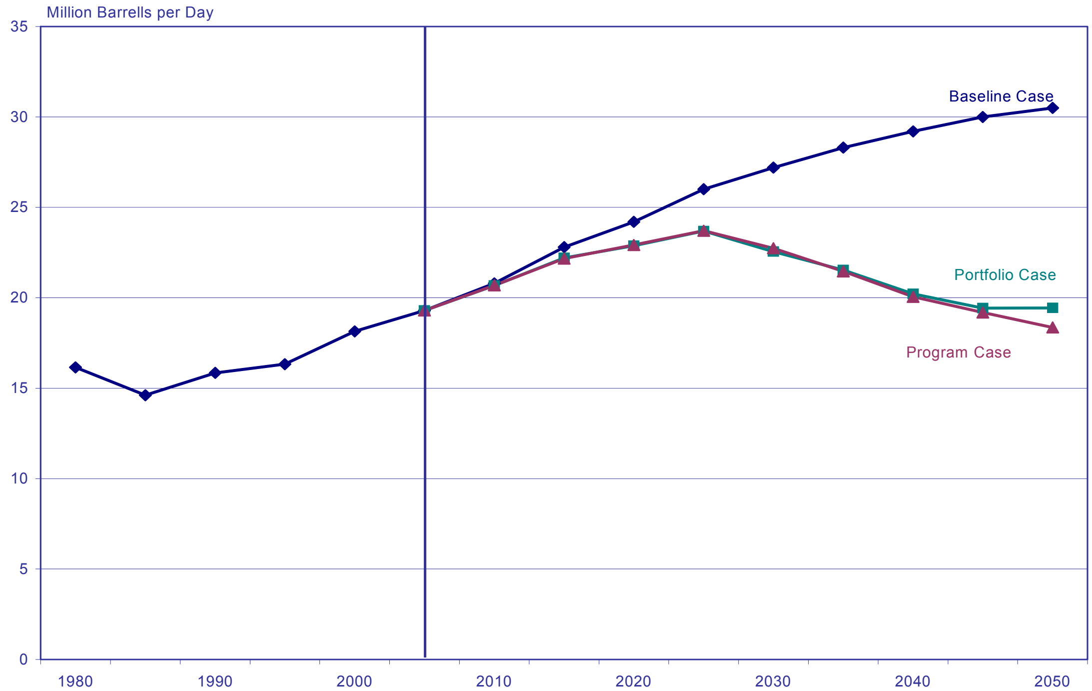

Figure 3.5. U.S. Oil Consumption, 1980-2000, and Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html. Data were converted from quads to mbpd using conversion factor of 1 quad = 0.472 mbpd.

While EERE's portfolio has elements that increase (as well as decrease) natural gas consumption; on balance, EERE's portfolio is expected to reduce annual natural gas consumption by about 1.8 quadrillion Btu from the baseline of 32.2 quadrillion Btu in 2025 and by 2.4 quadrillion Btu from the baseline of 36.6 quadrillion Btu in 2050 (**Figure 3.6**). While EERE does not estimate the portion of natural gas savings attributed to imported natural gas supplies, supplies from countries other than the United States and Canada may be the marginal sources of natural gas for meeting any future growth in demand.

EERE's technology programs also contribute to the security of the Nation's electricity supply by reducing central conventional power plant capacity additions. This is achieved through reduced demand for electricity (through improved efficiency or when coincident with renewable generation) and central renewable and distributed power additions. By 2025, EERE's portfolio is expected to reduce central conventional capacity additions by 137 gigawatts—by increasing central renewable and distributed power capacity by 144 gigawatts (some of which is intermittent and therefore displaces less conventional capacity). Increased efficiency reduces the need for 65 GWs of capacity (based on BT, Industrial, FEMP, and WIP programs, which do not take into account the integration effect in the Portfolio Case) (**Figure 3.7**). As shown in **Figure 3.8**, renewable energy capacity additions (central and distributed) are projected to grow by an additional 42 GW compared with the Baseline Case in 2025, and 137 GW compared with the Baseline Case in 2050.

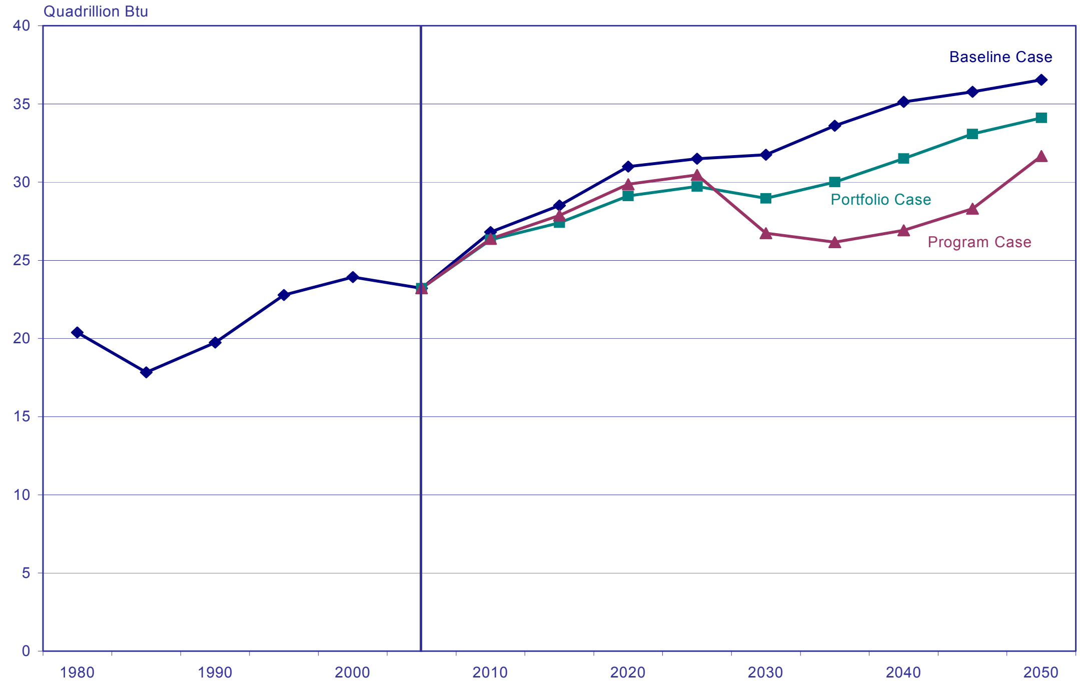

Figure 3.6. U.S. Natural Gas Consumption, 1980-2000, and Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 1.3, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

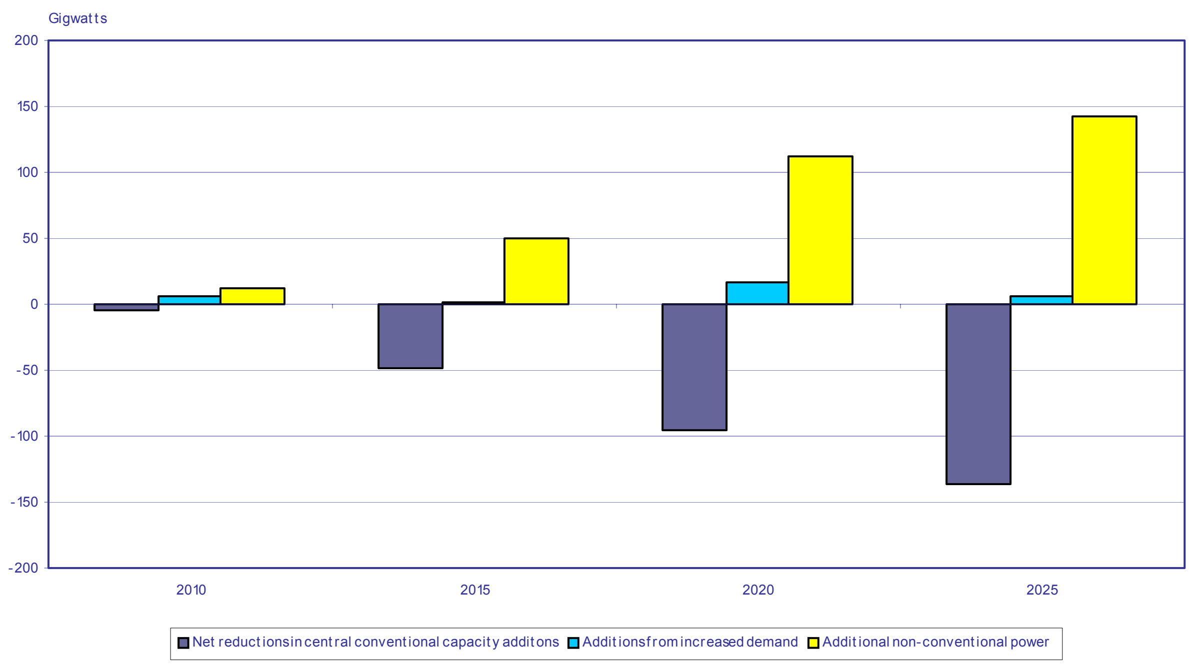

Figure 3.7. Impacts on Capacity Projections to 2025: Portfolio Case

Data Source: NEMS-GPRA06

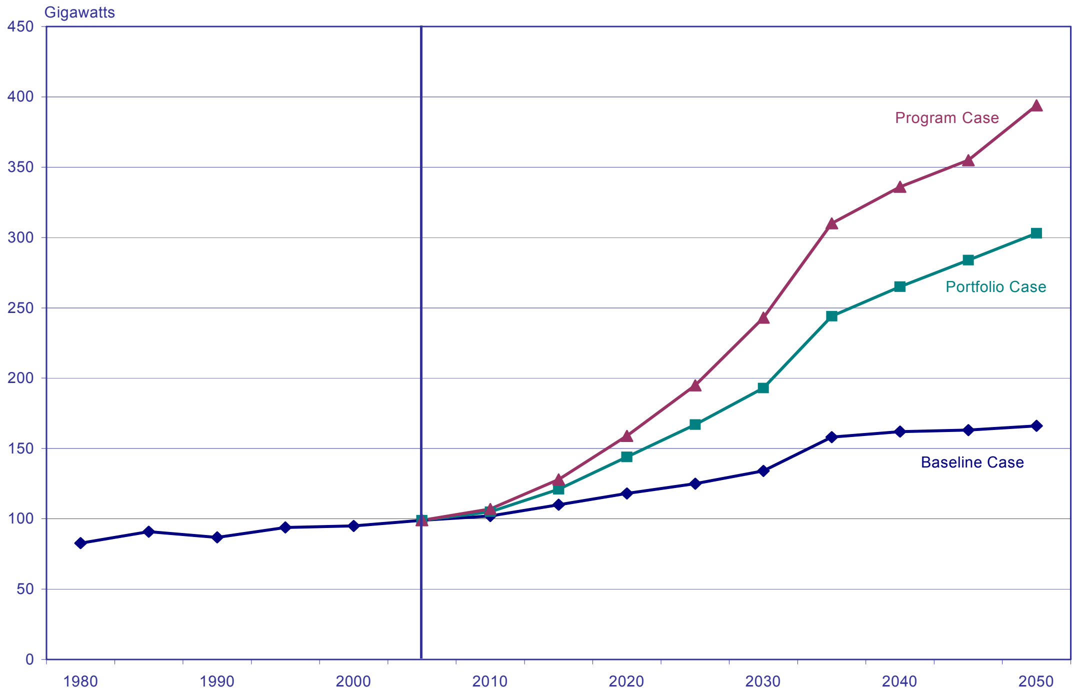

Figure 3.8. U.S. Renewable Energy Capacity, 1980-2000, and Projections to 2050: Baseline, Program, and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2003*, DOE/EIA-0384 (2003) (Washington, D.C., October 2004), Table 8.11a, Web site http://www.eia.doe.gov/emeu/aer/contents.html.

Program Benefits

The remainder of this chapter is devoted to program-specific information, including program budget requests and benefits. See **Chapter 4** and **Chapter 5** for more specific program-level analysis. **Figure 3.9** displays the EERE program budget requests for FY 2006. The largest program budget is $310 million for the Weatherization and Intergovernmental Program (WIP), which includes $225.4 million for Low-Income Weatherization Assistance.

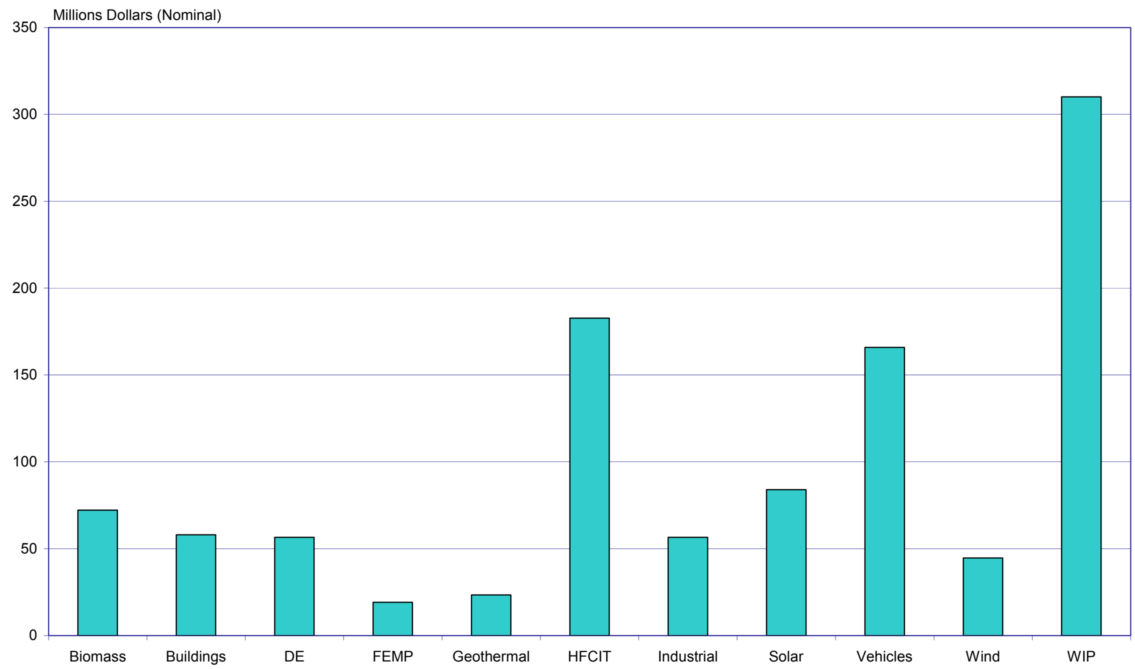

Figure 3.9. EERE Program FY 2006 Budget Requests

Source: Budget request from *FY 2005 Budget-in-Brief*, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, http://www.eere.energy.gov/office_eere/pdfs/fy05_budget_in_brief.pdf.

The FY 2006 estimates of benefits for the individual EERE programs are shown for 2025 and 2050 in **Figures 3.10 through 3.16**. The benefits vary widely across EERE's programs, with each program providing a different level and mix of benefits. Often, individual programs target different types of benefits. Nonrenewable energy savings in 2025, for example, range from 0.06 quadrillion British thermal units (Btu) for the Federal Energy Management Program (FEMP) to 3.98 quadrillion Btu for the Vehicle Technologies Program (**Figure 3.10**). The differences in benefits result from a number of factors: (1) program size and target market; (2) time frames for program results and reported benefits; (3) primary types of benefits addressed by each program; (4) technical potential achievable within each program beyond the Baseline Case, and (5) ability to assess program goals or target markets with current capabilities. Note that these estimates do not reflect the relative performance risk associated with these program activities.

Several EERE programs are targeted toward benefits not well reflected in any of EERE's quantified benefits metrics. For instance, the Distributed Energy (DE) Program focuses on improving electricity reliability by developing electricity-generating capacity at or near the point of use (**Figure 3.16**). However, EERE does not currently have the capability of quantifying the level or value of improved reliability, or of reflecting the consumer value for reliability in estimated future market purchases. Similarly, the State Energy Grant Program funds the development of State energy plans, including energy emergency planning. This key component of homeland security is not reflected in any of the security metrics in this analysis. In the case of the Biomass Program, there has been a substantial redirection of the research toward integrated biorefineries that will produce a mix of high-value chemicals, as well as fuels such as ethanol and electric power. These are very complex systems, and EERE does not yet have an adequate modeling capability for this, as described in **Chapters 4 and 5**.

While incomplete, the results indicate both the range and approximate level of benefits available to the Nation from funding the efficiency and renewable investments in EERE's portfolio of programs. They indicate a potential for making better use of existing technologies and for accelerating technological advances to make significant changes in our energy markets, which can drive the Nation to a period of level energy consumption.

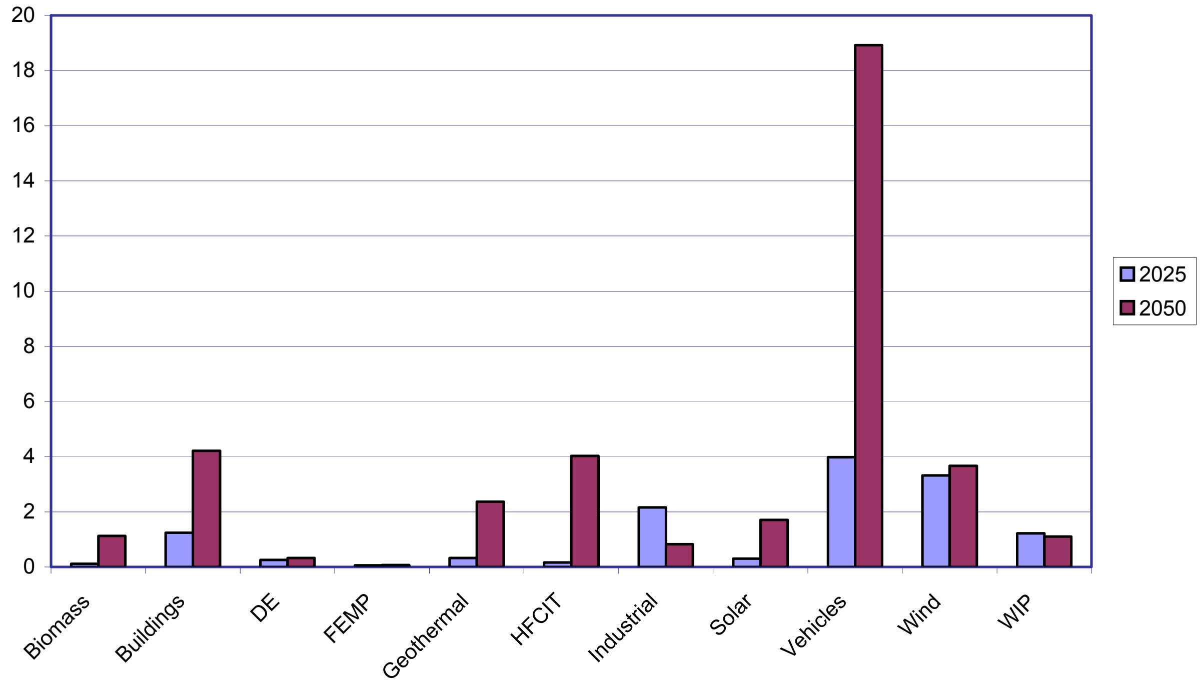

Figure 3.10. Annual Nonrenewable Energy Savings: 2025 and 2050 (quadrillion Btu)

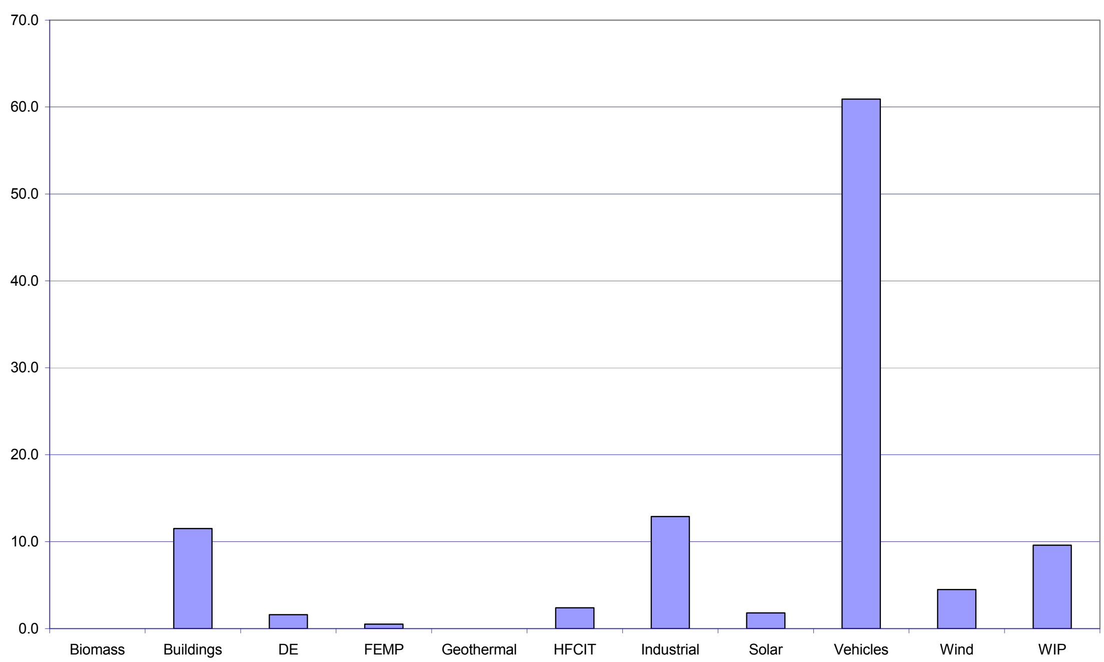

Figure 3.11. Annual Energy Expenditure Savings: 2025 (billion 2002 dollars)

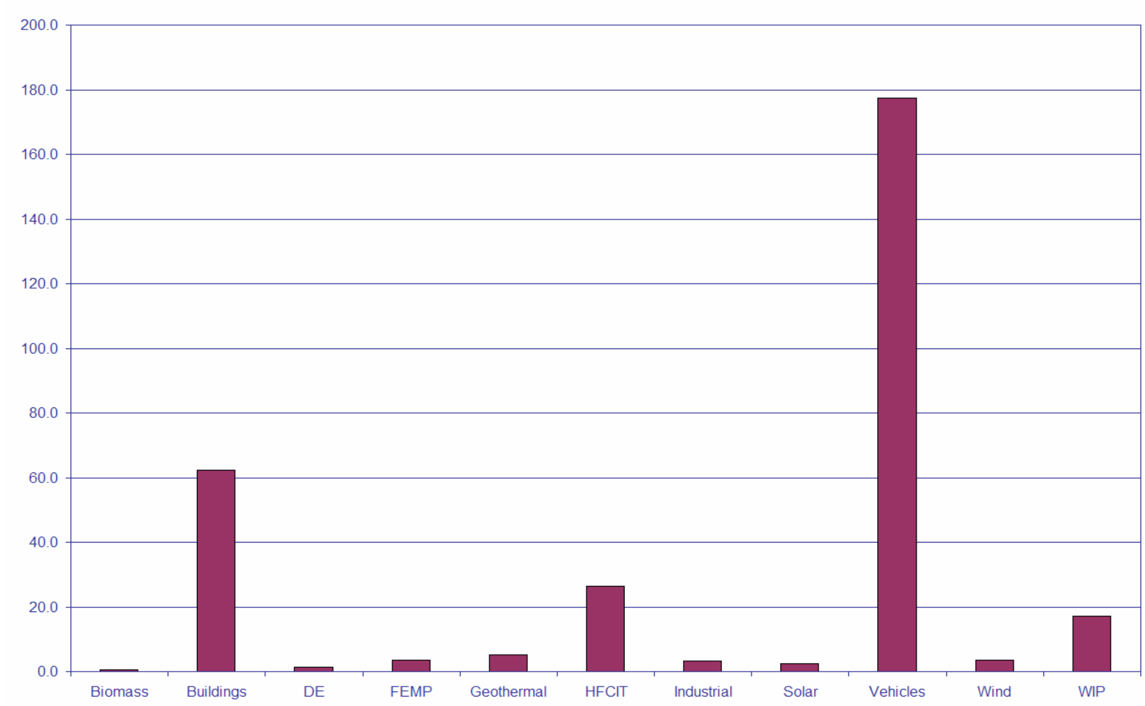

Figure 3.12. Annual Energy-System Cost Savings: 2050 (billion 2002 dollars)

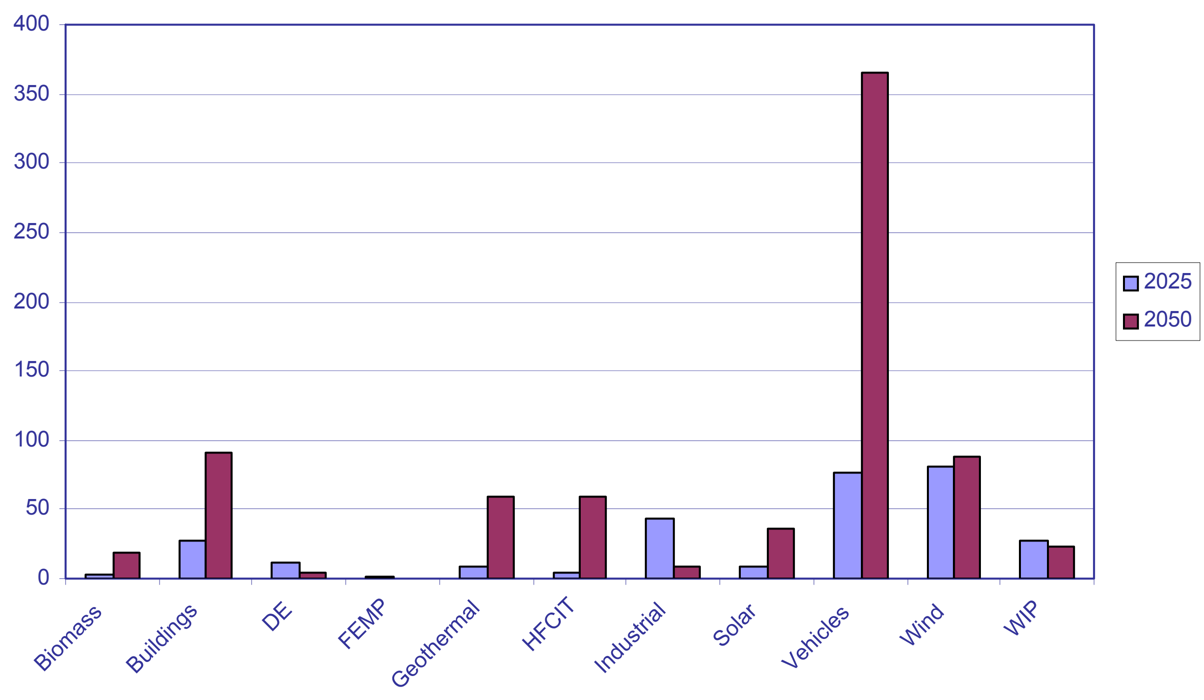

Figure 3.13. Annual Carbon Dioxide Savings: 2025 and 2050 (mmt carbon equivalent)

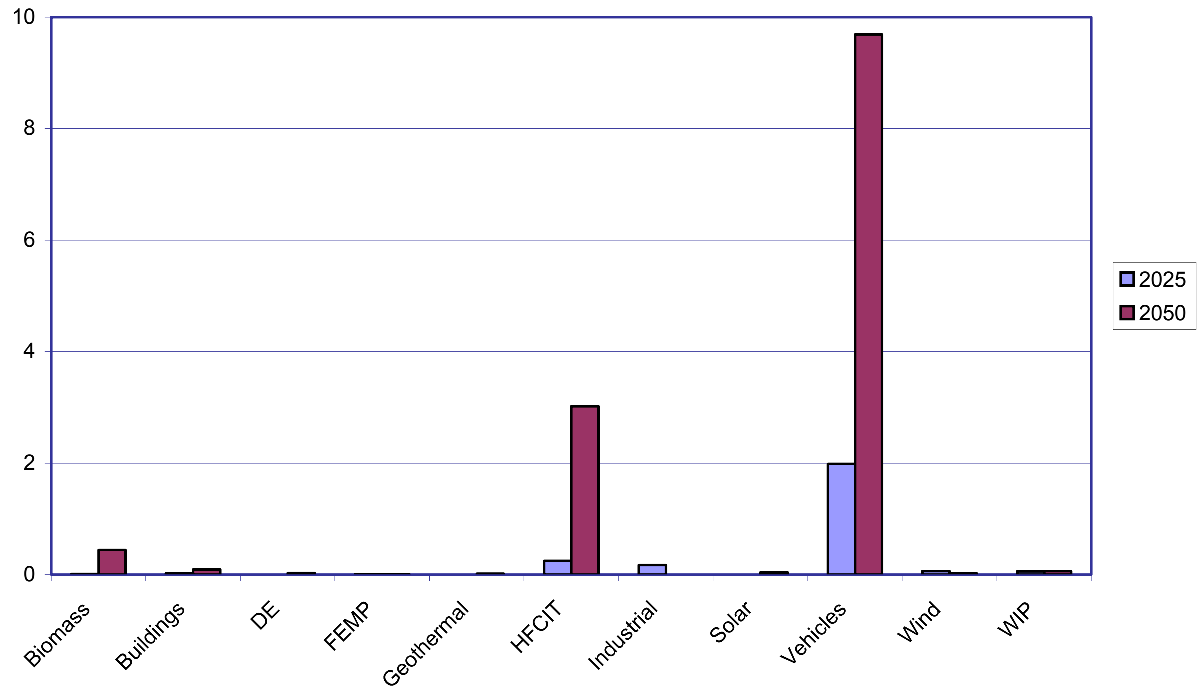

Figure 3.14. Annual Oil Savings: 2025 and 2050 (mbpd)

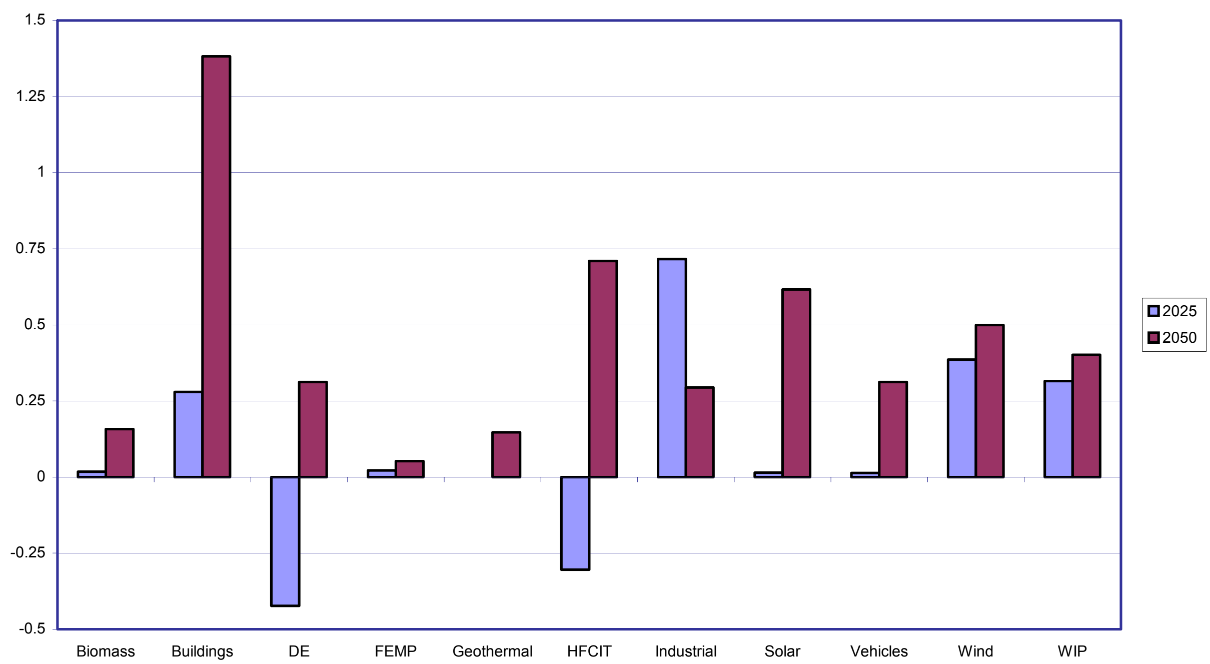

Figure 3.15. Annual Natural Gas Savings: 2025 and 2050 (quadrillion Btu)

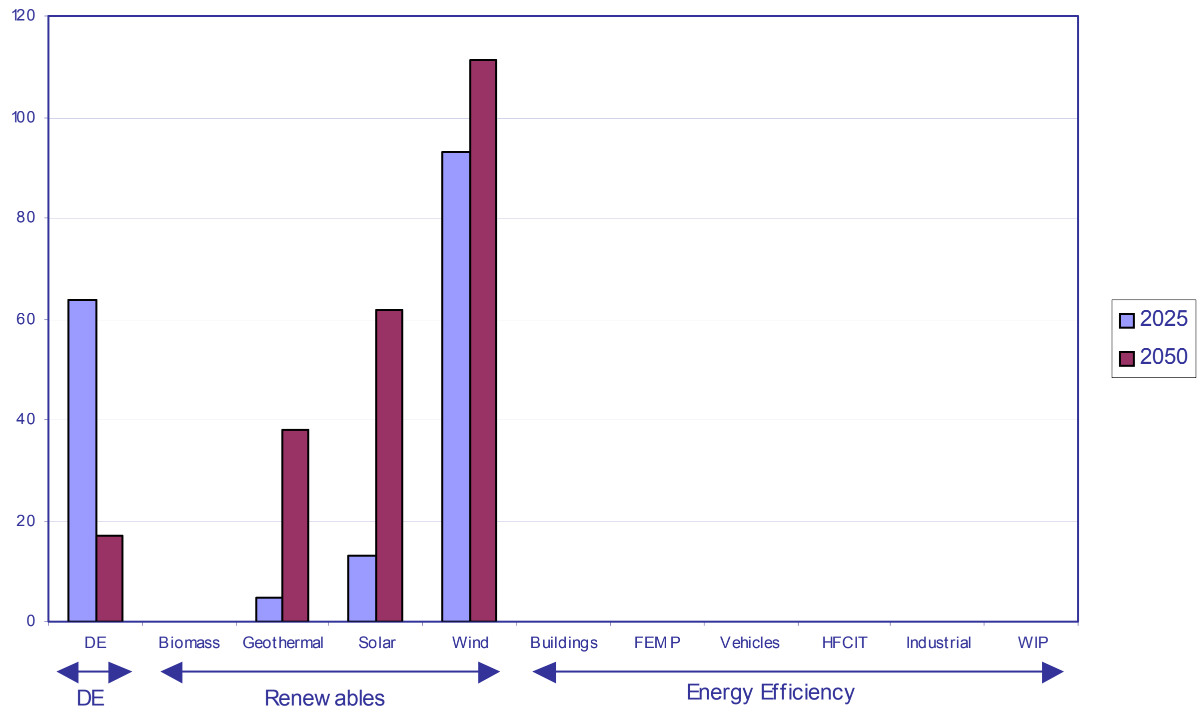

Figure 3.16. Annual Electric Generating Capacity – DE, Renewables, Energy Efficiency: 2025 and 2050 (gigawatts)

Note: Capacity for the DE Program includes gas-fired combined heat and power (CHP) systems in commercial and industrial applications and non-CHP grid support applications. Renewables include distributed and central station capacity. The Biomass Program does not create additional capacity because it is aimed at developing biomass refineries. The Buildings, FEMP, Vehicle Technologies, Industrial, and WIP programs do not create additional electric generating capacity because they are efficiency programs. Some of the efficiency programs do, however, reduce the need for additional capacity. The HFCIT Program includes fuel cell capacity.